McGregor Model Forest

Inventory Plan

MINISTRY OF FORESTS
RESOURCES INVENTORY BRANCH
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Table of Contents

1. INTRODUCTION 1

1.1 Background 1
1.2 Objectives 2

2. BUSINESS CONSIDERATIONS 3

2.1 Forest Management Issues 3
2.2 Inventory Issues 4

3. INVENTORY PLAN 5

3.1 Provincial Inventory 5
3.1.1 Provincial Inventory Landbase 5
3.1.2 Objectives 5
3.1.3 Sampling Plan 6
3.2 Management Inventory 7
3.2.1 Management Unit Landbase 7
3.2.2 Objectives 8
3.2.3 Sampling Plan 8

4. IMPLEMENTATION STRATEGY 9

4.1 Steps 9
4.1.2 Implementation Process 10
4.2 Cost 11
4.2.1 Provincial Inventory 11
4.2.2 Management Inventory 12
4.2.3 Combined Management and Provincial Inventories 12
4.3 Monitoring 13

5. APPROVAL/SIGNING 14

APPENDIX A MCGREGOR MODEL FOREST VEGETATION RESOURCES INVENTORY GROUND SAMPLING PLAN

APPENDIX B POLYGON SELECTION

List of Tables

Table 1. Forest management issues in the McGregor Model Forest. 3
Table 2. The estimated sample size required to implement the Provincial Inventory.....7
Table 3. Area by Inventory Unit within the McGregor Model Forest.....7
Table 4. Estimated costs required to complete the Provincial Inventory sample plan. ...11
Table 5. Estimated costs required to complete the Management Inventory sample plan.12
Table 6. Combined costs to complete the Management and Provincial Inventory sample plan.....12

1. INTRODUCTION

1.1 Background

The Provincial Vegetation Resources Inventory (VRI) or Provincial Inventory is an improved vegetation (forest) inventory process or toolbox for assessing the quantity and quality of British Columbia's timber and other vegetation resources. It addresses the concerns expressed by the Forest Resources Commission in its 1991 report, *The Future of our Forests*. These concerns included:

- lack of statements of precision of the inventory;
- inadequate information on non-timber vegetation resources;
- lack of reliable estimates of growth rates and stand specific volumes; and
- narrow focus on commercial timber volume and the timber harvesting landbase.

The VRI can be implemented at a number of levels depending on the business needs. It can be deployed over the entire province (one or more Forest District at a time), measuring all the timber and non-timber resources. The VRI can also be deployed over a Management Unit (TFL or TSA) or a small watershed within a District, measuring selected resources in specific portions of the landbase.

The Provincial Inventory consists of a system of protocols, models and databases that can be managed through a dispersed computing environment. The Provincial Inventory process can be used to meet today's needs for timber supply, long term planning, silviculture planning, defining sustainability, public information and credibility. The Provincial Inventory can also provide data for computer modeling and decision support systems to support a baseline biodiversity assessment and for research.

The Vegetation Resources Inventory is designed to determine:

- the amount of vegetation cover in the province;
- the location of vegetation resources in the province; and
- the changes in the amount and location of vegetation resource over time.

The principles guiding the implementation of the inventory are:

- to integrate provincial inventory activities (e.g. Management Inventories, Provincial Inventory, National Forest Inventory and Monitoring);
- to implement inventory projects to satisfy business requirements as defined in the inventory plans; and
- to maximize the usefulness of sample plots and minimize overall costs by implementing a cascading plot approach that ensures that information collection meets the VRI standards while meeting multiple goals.

Management Inventories include inventories conducted in Implementation Units[1], to fulfill specific forest management or business needs. Sampling error and sampling intensity are controlled for specific vegetation attributes (e.g., timber volume) to achieve specific inventory objectives. There are several types of Implementation Units in the province: Timber Supply Areas (TSAs), Tree Farm Licenses (TFLs), and other lands (parks, private lands, and other public lands). Within (or across) these Implementation Units there may be Management Inventories addressing specific issues such as Problem Forest Types, or other strata in a TSA (or groups of TSAs).

Management Inventories are typically timber emphasis inventories. Besides providing detailed polygon information for day-to-day forest management, they can also be used to increase precision of the Provincial Inventory. The TFL holders or the MoF Regions/Districts are responsible for the planning and implementation of these inventories. However, the Ministry of Forests Resources Inventory Branch requires the TFL holder(s), stakeholder(s), or District(s) to prepare an inventory business plan, which includes a sampling plan, for its approval. An inventory business plan defines the inventory needs, the information needed to meet the needs, and the methods for collecting the information. This business plan then drives the inventory project plans.

1.2 Objectives

This is a plan for implementing the Provincial and Management Inventory activities in the McGregor Model Forest in the Prince George Forest Region. This plan was developed through consultation with various stakeholders during May 1997 in the McGregor Model Forest, including the Ministry of Forests, Branch, and Region staff, McGregor Model Forest Association, and Northwood Pulp and Timber Limited (TFL 30) staff who identified inventory local needs and priorities. Management issues identified in the recent timber supply review in the TSA were also reviewed.

The purpose of the Inventory Plan is to:

1. define the Management Inventory objectives;
2. define the Provincial Inventory strategy for McGregor Model Forest (MMF);
3. identify the inventory activities required to satisfy the objectives for both inventories; and
4. outline the implementation steps.

This plan is based on the consultant report, *McGregor Model Forest District Vegetation Resources Inventory Ground Sampling Plan,* prepared by J.S. Thrower & Associates. The report was prepared following the procedures outlined in the Ministry of Forests, Resources Inventory Branch procedures, *Vegetation Resources Inventory: Preparing a*

[1] Implementation Units are a specified area of land such as a TSA, TFL, Innovative Forest Practices Agreement area, etc. For any Implementation Unit, there can be none to several Management Inventories based on stakeholder business needs.

sampling plan for ground sampling (March 1997). The report has been reviewed by stakeholders and is attached to this Inventory Plan (Appendix A).

2. BUSINESS CONSIDERATIONS

2.1 Forest Management Issues

Forest management issues were identified during the recent timber supply review (Table 1). An assessment of potential impacts of the VRI ground sampling on these management issues is also shown in this table.

Table 1. Forest management issues in the McGregor Model Forest.

	Management Issues[2]	Remarks
1.	Timber inventory: actual vs. expected volumes.	Improved timber net volumes will be obtained by removing overall bias observed in the inventory audit. Statistical statements of accuracy for the overall inventory will be provided. The plots could also be used to quantify incidence of the pine leader weevil and root rot in the MMF. The VRI plots could be used to help identify causes of discrepancy between actual volumes and VDYP predicted volumes.
2.	Site productivity: site index of second-growth stands.	The Phase II plot results could be used to check existing site index estimates but not the accuracy of future second growth stands. The OGSI and SIBEC studies may be useful for this purpose.
3.	Minimum harvestable age.	Application of the Inventory.
4.	Regeneration impediments.	The Phase II plots could be used to check how much MMF area (spruce stands) is actually under attack by the pine leader weevil.
5.	Biodiversity/LRMP.	Phase II will provide totals for non-timber vegetation such as coarse woody debris, stumps, potential wildlife trees, range forage and plant lists for species diversity. This information can be used to check the existing biodiversity guidelines in the Prince George Forest District. This information can also be used to measure indicators of sustainable management and provide a basis for additional sampling. There is a risk that precise estimates will not be obtained for these attributes.
6.	Yield curves.	The Phase II sampling will provide unbiased overall volumes for the next timber supply review and a basis for localizing the yield curves used to project the inventory.

[2] BC Ministry of Forests, Timber Supply Branch. 1996. *Forest Management Issues Identified Through the AAC Determination Process. TSA/TFL Timber Supply Reviews: 1992-1996.* Victoria BC. pp 261-263.

2.2 Inventory Issues

The most recent Timber Supply Review and the Inventory Audit identified specific issues and information to improve the timber inventory. Some of the issues and information identified by the Ministry of Forests, McGregor Model Forest Association and TFL 30 staff include:

- The 1995 Inventory Audit of the McGregor Model Forest indicated that mature timber volumes in the inventory may be over-estimated on average by approximately 15%. This was probably because of the lower stocking in many of these stands, which is not reflected well in VDYP predictions (Issue #1, Table 2).
- Measurement and monitoring local indicators of sustainable management for the MMF. These include indicators of forest health, natural disturbance patterns, wildlife habitat and site productivity (Issue #5).
- Site index under-estimation for old-growth stands (Issue #2).
- Taper equation bias is suspected in the high-elevation balsam and spruce stands (Issue #1).
- Decay, waste, and breakage factors mainly in the spruce/balsam stands are in question (Issue #1).
- The uneven-aged "intermediate utilization" logged stands are modeled as even-aged stands (Issue #1).
- Pine leader weevil damage in the spruce stands, and root rot in the Douglas-fir stands (Issue #1).
- Loss of inventory resolution through age-class mid-pointing, particularly in age class 8 stands (141-250 years, or 195 years), which represents about 50% of the MMF operable landbase (Issue #1).
- Provincial and District monitoring of the indicators of sustainable forest management, as defined by the Canadian Council of Forest Ministers (CCFM).[3] Monitoring would involve measuring changes and trends in some of these indicators, which include percent and extent of area by forest type and age class, and mean annual increment by forest type and age class.

- Issues raised by the Forest Resources Commission's 1991 report, *The Future of Our Forests*, regarding the inadequacy of forest inventories in the province. These concerns included lack of statements of precision on the inventory, inadequate information on non-timber vegetation, and the narrow focus on commercial timber volume and the operable landbase.

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[3] Canadian Council of Forest Ministers. 1995. *Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators*. Natural Resources Canada, Canadian Forest Service, Ottawa, ON. 22pp.

3. INVENTORY PLAN

3.1 Provincial Inventory

3.1.1 Provincial Inventory Landbase

The landbase for the Provincial Inventory is the McGregor Model Forest. Typically, the inventory unit for the Provincial Inventory is one or more Forest Districts. However, the MMF will be treated as a separate inventory unit, independent of the rest of the Prince George Forest District[4]. Eventually, overall VRI totals and averages for the entire District can be obtained by appropriately combining the MMF statistics with those of the remainder of the District.

The MMF covers approximately 180,500 hectares and is located in the Prince George Forest District in the Prince George Forest Region. This area represents approximately 10% of the Prince George Forest District. Approximately 88% of the MMF is considered potentially productive[5]. The remaining areas include non-forest and non-productive land (approximately 12%). The MMF is divided into three landscape units, includes seven BEC subzones, and does not contain any ecological reserves or parks.

3.1.2 Objectives

3.1.2.1 Photo Interpretation

Photo interpretation work is recommended for the Provincial Inventory within the McGregor Model Forest. New delineation and photo estimation work is in progress.

3.1.2.2 Ground Sampling

The objective of the Provincial Inventory ground sampling in the McGregor Model Forest is to provide overall totals and averages for timber and non-timber vegetation resources. The Provincial Inventory ground sampling will aim to achieve a sampling error of $\pm$10% (at the 95% probability level) for net timber volume in the treed portion of the MMF and to allow for calculation of sampling errors for other VRI attributes. The Provincial Inventory will cover the *entire* MMF including the timber harvesting landbase, inoperable landbase, recreation areas, and private lands. The key attributes of interest are stand age, net volume by species, stand height, and species composition. The variability of these tree attributes will be used to set the sample size for the Provincial Inventory.

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[4] This decision was made by the MOF Director of Resources Inventory Branch in consultation with the MMF Association staff. The reasons for this decision were the unique nature of TFL 30 as a model forest and logistic considerations.

[5] Northwood Pulp and Timber Ltd. 1995. Data package in support of MP #8. Summary tables provided by Bob Doratty, 20 March 1997.

3.1.3 Sampling Plan

3.1.3.1 Sample Size

To achieve the inventory objectives as identified above, the sample sizes required to implement the Provincial Inventory are summarized in Table 2. In inventory, a sampling error standard is necessary to provide a basis for determining sample size. In the VRI, the allowable sampling error standard is set at ±10% for volume estimation at the management unit level (typically a Forest District). This standard does not apply to other attributes in the inventory.

The number of samples required to achieve the standard is a function of the variation within the inventory unit, estimated by the coefficient of variation (CV%). The estimated CV in the McGregor Model Forest used to estimate the total number of plots to achieve a sampling error of ±10% for net volume is 52%[6]. To achieve the VRI standard at a reasonable cost, two types of VRI plots will be used:

- full VRI samples, where the full suite of information (timber, coarse woody debris, range and ecology) is collected; and
- tree emphasis samples, where only tree information is collected.

The total number of full VRI samples (50) will be adequate to achieve a sampling error of ±15% in the treed landbase. Tree emphasis samples (TEP) (60) will then be used to reduce the sampling error in the treed landbase to ±10% to achieve the standard.

In the remaining non treed area of the unit, the number of full VRI samples (40) established will be the ratio of the treed to remaining landbase, multiplied by the number of treed VRI samples required to achieve a sampling error of ±15%.

Implementing the two types of samples will ensure a minimum number of full VRI plots are established across the landscape to collect the full suite of VRI information. Establishing TEPs to boost the number of plots required to achieve the VRI standard will result in saved time and money.

To complete the Provincial Inventory, NVAF (net volume adjustment factor) and WPV (within polygon variation) sampling are required. The number of these types of samples are contained in Table 2.

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[6] The inventory audit CV was inflated by 25% to account for the possible differences between the CV estimates based on the VRI design (a tight 5-plot cluster) and based on the inventory audit (a well-distributed 9-plot cluster).

Table 2. The estimated sample size required to implement the Provincial Inventory.

Ground Sampling Activity	Sampling Unit	VRI Samples	Tree Emphasis Samples	Sample Size
Provincial Inventory				
Vegetated Treed	Cluster	50	60	110
Other	Cluster	40	-	40
Net Volume Adjustment Factor	Tree	75		75
Within Polygon Variation	Polygon	30		30

3.1.3.2 Provincial Inventory Sampling

To achieve the Provincial Inventory objective, the sampling should be implemented in a two-step process. Step 1 is to install approximately 100 sample clusters in the first field season over the entire MMF. Step 2 is to install the remaining sample clusters in the second field season. The sampling locations will be selected systematically from the sorted list of potential sampling points. This list will include all polygons in the MMF and will be sorted by non-vegetated/vegetated and then land type, leading tree species, age, and site index. Sampling in the first year will provide experience to refine the process for the second field season, and information to calculate precisely the remaining number of samples required to meet the precision target of ±10% for total net volume in the treed portion of the MMF. An estimated total of 150 sample clusters will be assumed for planning, training, and other logistic considerations. Matching unavailable sampling sites with sub-sampling of sample clusters with difficult access will be anticipated and planned for, as these activities will increase inventory costs.

A two-step approach should also be used for implementing the other ground sampling activities that support the Provincial Inventory process: NVAF sampling and WPV sampling. NVAF provides a factor to adjust the net volume from the ground sampling (derived from the net factoring process and taper equations) to account for hidden decay and possible bias in taper equations. WPV information is used to express the total error of the inventory and to indicate accuracy of individual polygon estimates. A total of 75 sample trees for NVAF sampling (selected from 15 treed and 1 non-treed polygons) and 30 sample polygons for WPV sampling are required.

3.2 Management Inventory

3.2.1 Management Unit Landbase

For the McGregor Model Forest, the Management Unit is the *treed landbase* as defined by the BC Land Cover Classification system. Table 3 provides an approximation of the area to be assessed by the Provincial and Management Inventories.

Table 3. Area by Inventory Unit within the McGregor Model Forest.

Inventory Type	Inventory Unit	Area (ha)

Provincial Inventory Management Unit	McGregor Model Forest	1,124,000
	Treed Landbase	635,000
	Intermediate Utilization	Not Available
	Lichen Loading	Not Available

3.2.2 Objectives

3.2.2.1 Photo Interpretation

Photo interpretation activity is in progress.

3.2.2.2 Ground Sampling

The ground sampling objectives for the Management Inventories are to:

- *Treed Landbase*: to improve the accuracy of timber volume inventory in the "treed" portion of the landbase in the MMF. The number of samples will ensure at least $\pm$10% sampling error (at the 95% probability level) for timber volume in the "operable" landbase in the MMF. This objective addresses the timber volume and site productivity issues in preparation for the next timber supply review.
- *Intermediate Utilization*: to estimate the merchantability of the "intermediate utilization" (IU) stands in the MMF. These stands include the balsam residual stands and the interior Douglas-fir (Fdi) stands in the SBS and ICH zones.
- *Lichen Loading*: to estimate the amount of arboreal lichen loading (kg/ha) in the high elevation balsam stands in the Caribou Management Areas

3.2.3 Sampling Plan

To achieve the objectives of the Management Inventories, Timber Emphasis Sampling will be required. The Timber Emphasis Sampling must meet the minimum sampling requirements as specified in *Implementation Strategy to Integrate Management, Provincial and National Inventories* (MoF, Resources Inventory Branch) The supplemental sampling will involve the installation of approximately:

- 250 sample clusters in the t*reed landbase*;
- 250 sample clusters in Intermediate Utilization stands; and
- the number of sample clusters to estimate lichen loading in the high elevation balsam stands is not available

The implementation should proceed in a manner similar to the Provincial Inventory ground sampling. The sampling will be spread over a period of 2 years, with unbiased interim results expected after the first season. Sampling in the first year will provide experience to refine the process for the second field season and information to calculate precisely the remaining number of samples required to meet the precision target of $\pm$10%.

The supplemental sampling should focus on tree attributes including call grading, net factoring and sub-sampling trees for stem analysis (addressing only decay, not breakage and waste).

NVAF sampling is not required for Management Inventories however it is strongly encouraged. Stakeholders should identify within their more detailed *Inventory Plans*[7] if NVAF sampling is to be conducted.

4. IMPLEMENTATION STRATEGY

The ground samples that are established to meet the Management Unit objectives are compatible with the Provincial Inventory objectives providing that these dual-purpose plots are identified prior to establishment. Therefore, Provincial Inventory plots will be identified prior to identifying the Management Unit ground sampling plots. These coincident plots will be used for both the Provincial and Management Inventories. Additional Management Inventory samples will be established to meet Management Inventory objectives. This integrated approach, that uses one set of samples to address multiple inventory needs, will result in minimum implementation costs.

Additional Provincial Inventory ground samples will need to be established in the non-Management Inventory area in order to complete the Provincial Inventory for the McGregor Model Forest.

The inventory outlined above will be completed to the Ministry of Forests minimum standards as outlined in *Implementation Strategy to Integrate Management, Provincial and National Inventories*.

4.1 Steps

There are several ways to complete the ground sampling in the two-step process stated above. It is hoped that stakeholders will complete all the required ground sampling in a timely manner. One possible scenario is as follows:

1. Install a large number of each Management Inventory sample clusters (e.g., 100) over the entire landbase measuring *only those* tree attributes related to timber volume and site index. Install the Provincial Inventory samples for plots that are designated "multi-purpose" and install tree emphasis plots for the others. This will provide the experience to refine the process for the second field season and will provide information to calculate the required number of remaining sample clusters.

[7] Inventory Plans are required by stakeholders in order to proceed with their Management Inventories.

2. Install the remaining Management Inventory sample clusters in the second field season. (Note: the stakeholder may choose to install all ground samples in one field season).

4.1.2 Implementation Process

The implementation process will proceed based on available funding and can be implemented based on a number of scenarios. All implementation scenarios will a common process. One possible implementation process could proceed as follows:

1. Assemble all polygons within the District into one list; check to ensure no areas are missing or double counted.
2. Sort the polygon list according to the criteria: BC Land Cover Classification code, estimated leading tree species, age, and site index.
3. Select potential sampling points from the sorted list, as described in the Ministry of Forests, Resources Inventory Branch document *Vegetation Resources Inventory: Preparing a sampling plan for ground sampling.*
4. Stratify list to *vegetated treed* and *remaining area* (non-vegetated, vegetated non-treed).
5. Systematically select the Provincial Inventory samples by stratum.
6. Systematically select the polygons for the WPV sampling from the list of Provincial Inventory samples.
7. Systematically select the 16 NVAF sample points (15 treed and 1 non-treed whether or not volume is indicated) from the Provincial Inventory ground samples.
8. Stratify the District to determine the Provincial Inventory samples that meet Management Inventory objectives. Subtract this number of samples from the total required for each Management Inventory. Select the remaining number of Management Inventory samples.
9. For each Management Inventory, systematically select a batch of sampling points from the list of operable sampling points (80% of the sample size) and from the list of inoperable sampling points (20%).
10. Begin planning for field sampling.
11. Prepare a field sampling plan that includes sample cluster batches to ensure an unbiased sample is attained at the end of the first field season. Identify NVAF sample points and ensure they are field sampled early in the field season.
12. Locate and measure ground sample clusters.
13. Monitor quality assurance of field data and procedures during field sampling. Arrange for 'audit quality cruisers' to sample auxiliary plots of NVAF samples.

14. Compile the data in the fall and winter of the first year. This will include computing averages of timber volume, basal area, and regression of photo estimated volume to ground sample volume and the associated standard error of the regression.
15. Prepare NVAF tree sampling matrix. Begin NVAF destructive sampling.
16. Prepare for the second step during the winter. This will include calculation of the CV based on the standard error of the regression. The remaining number of samples required to achieve the stated desired precision can then be accurately determined using standard procedures (see Appendix B).
17. Prepare the remaining samples.
18. Locate and measure remaining ground sample clusters in the second field season. Complete stem analysis of the NVAF sample trees. Complete the within polygon variation sampling.
19. Compile all data, do the statistical adjustments and load final inventory results into the provincial database.

4.2 Cost

4.2.1 Provincial Inventory

The Provincial Inventory costs, for planning purposes, are summarized in Table 4.

Table 4. Estimated costs required to complete the Provincial Inventory sample plan.

Ground Sampling Unit	Sample size	Unit Cost* ($)	Total Cost ($)
Provincial Inventory			
Sample Cluster (VRI)	90	2,500	225,000
Sample Cluster (treed only)	60	1,500	90,000
Net Volume Adjustment Factor	75	500	37,500
Within Polygon Variation	30	1,500	45,000
Total			397,500

* The unit costs are based on experience gained from the Boston Bar Operational Trial.

A CV of 52% and the objective precision level of ±10% sampling error (at the 95% probability level) were used to estimate the required number of Provincial Inventory samples.

Sampling efficiency and cost effectiveness will be achieved by implementing the Provincial Inventory ground sampling in combination with the Management Unit sampling. Results of the VRI ground sampling can be evaluated to determine the additional sampling required to meet the specific objectives.

4.2.2 Management Inventory

The costs for completing the Management Inventory plan including the incremental cost of establishing the Provincial Inventory ground samples are identified in Table 5.

Table 5. Estimated costs required to complete the Management Inventory sample plan.

Ground Sampling Unit	Sample size	Unit Cost ($)	Total Cost ($)
Management Unit			
Treed Landbase	250	1,500	375,000
Intermediate Utilization	250	1,500	375,000
Lichen Loading	Not Applicable	1,500	Not Applicable
Total			750,000

The sample size determination for the Management Unit sampling can be found in the consultant report in Appendix A. The required number of Management Inventory samples is based on the appropriate CV (estimated) and the objective precision level of ±10% sampling error (at the 95% probability level).

The total cost could be higher or lower if the assumptions stated above are not valid. For example, an increase in the CV or a reduction in the desired precision level, will result in an increase in the number of samples required to achieve the objectives. The relationship between the sampling error and sample size is illustrated in the contractor report (Appendix A).

4.2.3 Combined Management and Provincial Inventories

Implemented separately, the total cost of the Provincial and Management Inventories would be approximately $1,147,500. Combining the inventory objectives through a common implementation strategy will realize a saving. Given the multiple Management Units within the Williams Lake TSA and their overlapping areas, it is difficult to estimate the magnitude of these savings. However, the savings on the Provincial Inventory samples would be approximately $165,000 based on implementing all of the vegetated treed VRI and tree emphasis samples in combination with the Management Inventory plots.

Table 6 illustrates the cost for one possible implementation scenario where overlap occurs between one of the Management Units and the Provincial Inventory. The total cost could be higher or lower if the assumptions stated above are not valid. For example, an increase in the CV or a reduction in the desired precision level will result in an increase in the number of samples required to achieve the objectives. The relationship between the sampling error and sample size is illustrated in the contractor report (Appendix A).

Table 6. Combined costs to complete the Management and Provincial Inventory sample plan.

Ground Sampling Unit	Sample size	Unit Cost ($)	Total Cost ($)
Management Unit			

Treed Landbase	250	1,500	375,000
Intermediate Utilization	250	1,500	375,000
Lichen Loading	N/A	1,500	N/A
Incremental Provincial Inventory Ground Sampling			
Sample Cluster (VRI)	50*	1,000	50,000
Sample Cluster (tree only)	60*	0	0
Provincial Inventory (Remaining)			
Sample Cluster (VRI)	40	2,500	100,000
Sample Cluster (tree only)	0	1,500	0
Net Volume Adjustment Factor - Tree	75	500	37,500
Within Polygon Variation	30	1,500	45,000
Total			982,500

*Tree information component to be captured as part of the Management Unit sample

The total cost could be higher or lower if the assumptions stated above are not valid. For example, an increase in the CV or a reduction in the desired precision level will result in an increase in the number of samples required to achieve the objectives. The relationship between the sampling error and sample size is illustrated in the contractor report (Appendix A).

Depending on the implementation strategy, the savings will vary. The savings realized reflect the comparative overlaps of the Management Inventories. The numbers in Table 6 reflect one possible implementation scenario. Costs will change depending on the actual implementation scenario chosen.

4.3 Monitoring

The Ministry of Forests, Resources Inventory Branch is responsible for monitoring this Inventory Plan.

5. APPROVAL/SIGNING

I have read and concur with the McGregor Model Forest Inventory Plan, June 19, 1998. It is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined within the plan. Modifications to this plan or more detailed plans need to be reviewed and approved by the signatories and then appended to this plan.

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General Manager
McGregor Model Forest Association

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Regional Manager
Kamloops Forest Region

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Director
Resources Inventory Branch

Appendix A

McGregor Model Forest
Vegetation Resources Inventory
Ground Sampling Plan

Appendix B

Polygon Selection